The Impact of Assistive Technology on Visually Impaired Computer Users Accessing the Internet

Pippa Coard

Whitireia Community Polytechnic
Wellington, New Zealand

p.coard@whitireia.ac.nz

Proceedings of the 15th Annual NACCQ, Hamilton New Zealand July, 2002 www.naccq.ac.nz

1. INTRODUCTION

The topic chosen can be broken down into two components: the first is the aspect of technology chosen: 'assistive technology'. I will be focussing in particular on the area of non-visual output technology. For the second component - the sector of society - I have chosen to focus on visually impaired computer users accessing the Internet. The term visually impaired includes both totally blind (functionally blind) as well as people with low vision (legally blind).

As a tutor at Whitireia Community Polytechnic last year I had the privilege of having two visually impaired students in my class - both losing their sight progressively as the result of a degenerative disease. While they could still use a computer monitor (magnified) we spent some time discussing ways they could cope in the future. The Royal New Zealand Foundation for the Blind (RNZFB) worked closely with these students to ensure that technology and support were provided to ensure their success.

In an earlier year I had a student who was profoundly deaf and 'listened' by lip-reading. She was an excellent student who also helped other students in the class.

Both of these instances have made me think more closely about how well we provide for disabled people - while our campus is fully accessible to people in wheelchairs unfortunately we are not suitable for totally blind (because of unfenced walkways, no Braille labels and many physical hazards).

Closer to home my father went blind at a young age.

This particular topic should be of concern to us all - according to the Royal New Zealand Foundation for the Blind every year almost 1,500 New Zealanders go blind or experience significant sight loss. In America an estimated 10 million people are blind or visually impaired (M2 Presswire, 18 Jan 2001). While a small proportion of these people are born with visual impairment a far greater proportion have lost their sight as a result of accidents, disease or old age. Medical conditions such as tunnel vision and vision field loss reduce the area people can see at a time. Cataracts cause hazy vision - as if looking through translucent glass - and affect the way colours are seen (indeed Monet suffered from this).

As the 'baby boomers' approach old age, the number of visually impaired people will increase significantly. Compounding the situation is the fact that many baby boomers are savvy computer users who will expect to continue to use the Internet to meet their information needs.

Ray and Ray (1998) suggest a way to imitate vision impairment. Carry out a set of everyday tasks at your computer - make sure that you include tasks like reading and replying to e-mails, searching for something on the net and reading an online magazine. Now attempt the same tasks with a piece of translucent plastic draped over your monitor. They suggest that this approximates some degree of visual impairment - words may be hard to read, graphics lose clarity and colours are less easily distinguished.

Next they suggest attempting the tasks with your monitor partially obstructed - you may find it difficult to carry out the task if you cannot see the part of the screen that contains vital commands, e-mails may be hard to understand with parts not visible to you, navigation between Web pages may be difficult if you cannot locate the next or back buttons - this is an attempt to approximate partial sight impairment.

Finally they suggest trying the tasks with your monitor turned off - now you will be faced with an entirely new set of access challenges and have some idea of the challenges the computer can present for blind people.

This essay will firstly look at the development of assistive technology including some historical background. I will then look at the positive and negative affects of assistive technology on visually impaired computer users accessing the Internet. Finally I will briefly look to the future.

2. HISTORICAL BACKGROUND

Visual impairment is not a new phenomenon. Various strategies have been developed to help people deal with it. While carved tablets of stone were probably user-friendly to blind people I intend to start looking nearer to the present day. A timeline of developments relevant to this discussion is on the following page.

In 1784 French educator Valentin Haüy invented the printing of raised letters on paper and started the first school for the blind in the 1785 in Paris. In 1821 Charles Barbier, a French army captain, invented a system of point type based on groups of dots. Louis Braille adapted Barbier's system to use groups of one to six dots and it was this system that in 1832 was adopted by a conference in London as Standard English Braille. This is largely the Braille we know today.

Braille embossing machines were developed so that Braille books could be produced. In 1882 the Perkins School for the Blind became the first library to circulate Braille books.

In the 1930s the first talking books appeared. They used the technology of the reel-to-reel tape recorder. The invention of the cassette player in 1963 improved the portability of talking books and extended their use.

The development of sophisticated cameras with video displays allowed partially sighted people to view documents and pictures by greatly enlarging them. In addition they provided the facility to increase contrast to aid visually impaired people.

A Braille reading machine was developed - it worked like a copier where a hard-copy document was laid face down and the machine read the text aloud or translated it into Braille.

Electronic Books (e-books) have been developed for print-impaired users (this includes people with reading disabilities such as dyslexia). In NZ, RNZFB use volunteers to scan printed textbooks into a PC and then embed comments into the text to give the reader information about visual material included in the original printed document. The electronic text is then available on floppy disk or via e-mail.

Following on from electronic books, Digital Talking Books have been developed and these are an improvement on the electronic book that is read in a linear fashion because the reader can navigate around the electronic content of the book as they choose. According to the director of information systems research and development at the American Foundation for the Blind (quoted in Valenza, 2000), "digital talking books are perhaps the most exciting things since Braille or guide dogs".

While these developments were taking place, we entered the computer age - in 1981 IBM's release of the personal computer (PC) with its text-based operating system DOS marked the beginning of a new era in information. Ultimately the widespread adoption of the PC (despite IBM's initial scepticism) formed the basis for the success of the Internet. Today the Internet is accessed by millions of users for information and communication.

With the spread of the PC, assistive technologies have been developed to allow visually impaired people access to the world of computing. In the broader sense the term 'assistive technology' includes any

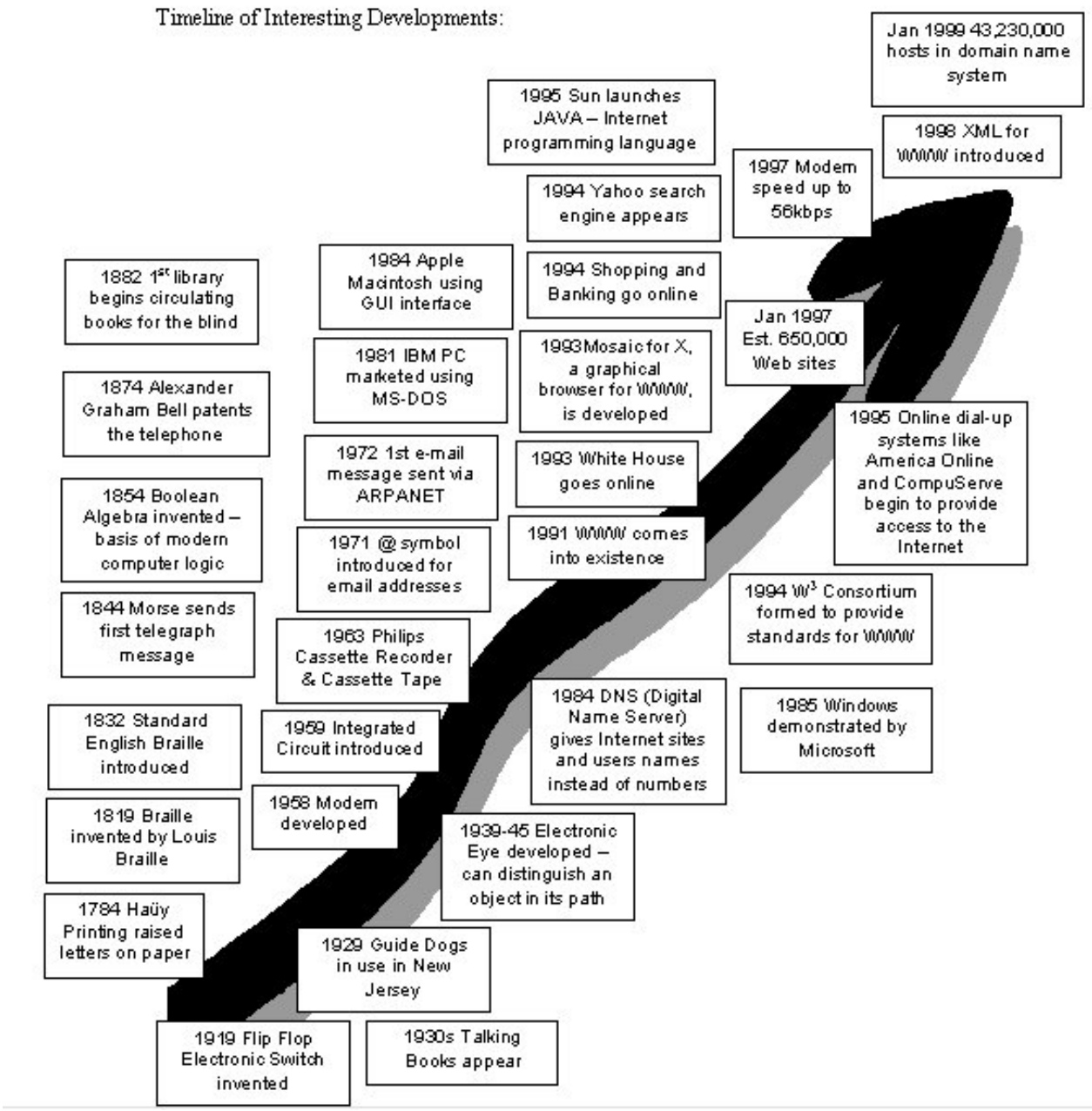

Figure 1: Timeline of Interesting Developments

technology that assists people to interact with the computer. Assistance may be with input such as allowing the user to navigate around the screen via the computer keyboard instead of the mouse and technology allowing the user to instruct the computer via a microphone rather than via the keyboard or mouse - Dragon Software's Naturally Speaking and IBM's ViaVoice are two such packages. Talking cursors are of great use to blind users - while I have had one as a novelty and to demonstrate to students, I am glad I do not have to rely on the artificial voice pleasantly repeating 'OK' or 'ENTER' when I hover the cursor over a button.

Assistive technology also includes ways of allowing disabled users to access outputs - and it is on this area - non-visual output - that I have chosen to focus for this essay.

Technologies that allow the reading of words have been in use for a long time - indeed in the late 1960s New Zealand banks introduced magnetic ink characters on the bottom of cheques and they are still there today. These characters are read via a process known as Magnetic Ink Character Recognition (MICR). Optical Character Recognition (OCR) has been developed to recognise letters - usually printed - and to interpret them into words. Scanners that allow a printed document to be scanned into a computer then turned into text to be edited by a word processor use the OCR technology.

A development of particular importance for non-visual output is that of screen reader software - this allows machine interpretation of the information displayed on the computer screen. Modern screen reader applications convert what is on the screen into recognisable words that can be output as speech using a speech synthesiser or to a Braille output device. They work best with text and a limited rage of graphics - such as in the Windows dialogue boxes and buttons.

In speech synthesis the computer 'voice' makes sounds that imitate human speech - but in a machine-like way without the inflection of human speech. Many products are now available, including:

- Dragon Systems: Dragon Naturally Speaking - (better suited to an English accent)
- IBM: ViaVoice (better suited to an American accent)
- Lernout & Hauspie: Voice Xpress Plus
- JAWS (Job Access with Speech for Windows). Developed in 1995 by the Blind/Low Vision Group of Freedom Scientific, JAWS 'reads 'HTML tables, frames, forms, graphic tags and the text common to most Web designs - then "recites" that content aloud" (Barbian, 2001). It is used by more than 50,000 users and has been translated into some 15 languages.
- In July 2000 Mindmaker released TextAssist 3.0 powered by FlexVoice - text-to-speech (TTS) technology that 'empowers the PC with the ability to synthesize human voices and read text out loud from any Windows text-editing application, ASCII text files, word-processing documents, e-mails, HTLL documents, and more' (M2 Presswire, 18 Jul 2000) and also includes facility to display text with a magnified font highlighting word-by-word as it generates the speech ... at the price of only US$19.00.
- There are many downloadable products - one such is Amaya available free from the World Wide Web Consortium (W3C).
- Not forgetting those who prefer the Macintosh, Apple Macintosh's operating system contains accessibility features called Universal Access - including CloseView (magnification utility), OutSpoken (screen reader utility) and EZAccess (allowing keyboard-only navigation).

One type of Braille output device is the refreshable Braille display - an electronic peripheral that raises or lowers an array of pins to create lines Braille characters. A Braille printer or embosser allows hard copy output - by embossing dots on to 100-pound paper.

These devices require a Braille translation software package to translate text into Braille - and these are readily available and include BrailleMaster (www.braillemaster.com) and MegaDots or Duxbury Translator (www.duxburysystems.com/products.asp).

Another type of assistive technology is screen magnification or enlargement - the technology to dramatically enlarge an entire screen or portions of the screen for low-vision users who may then be able to use a mouse to navigate. The magnification may be so great as to allow reading of only one letter at a time - requiring the reader to mentally reassemble the letters into words then sentences. ZoomText (from Ai Squared) is one magnification product on the market. In addition to magnification, some products change colours and/or provide better contrast for people with reduced vision.

3. IMPACT

While this overview of the assistive technology is necessarily brief and non-technical, I will now move on to look at the impact the technology has had on visually impaired computer users accessing the Internet.

Assistive technology in general has given visually impaired people access to the Internet and the World Wide Web (WWW) allowing them access to information and services that would otherwise be difficult or impossible to obtain. It is hard to adequately explain the significance of this because it has such far-reaching impacts - just as the Internet does for sighted users but many, many times more so.

Traditionally libraries have provided a print-based service - largely not easily accessible to the blind to whom mobility may also be an issue. The availability of Braille books is limited - indeed students frequently have difficulty in obtaining current versions of textbooks, sometimes only getting them after their course has finished! Braille books are also huge to carry around - according to Dick and Kubiak (1997) a small pocket dictionary occupies a bookshelf 61/2 feet high by 3 feet wide!

Now the Internet allows blind people access from their home to material they have never had access to before. The potential of the Internet is huge - as Dale McDaniel vice-president of Artic Technologies (quoted in McKeefry, 1998b) says “The Internet is a treasure trove of information for those that are blind or [have] low vision”. Information such as bus timetables, encyclopaedias, magazines, stock market quotes, information about obscure hobbies, travel brochures ... has been difficult for visually impaired people to access. Assistive technology offers the key to opening up the Internet to these people.

The Internet contains not just information but a huge number of goods and services that also may traditionally be difficult for the visually impaired to access. The task of grocery shopping is extremely difficult for a visually impaired person to carry out independently (how do you know what is where on shelves that are apparently without labels?) even if they have negotiated public transport to get to the supermarket. Online supermarkets, provided they are set up with the disabled in mind, could vastly improve this aspect of life. Likewise online shopping in general has the potential to offer greater independence to the visually impaired.

Electronic commerce via the Internet is another aspect where assistive technology can greatly assist the visually impaired. While Internet banking may not replace telephone banking (a valuable aid in the past), additional e-commerce services will be accessible on Internet sites accessible via assistive technology.

Education delivered via the Internet can provide opportunities for many disabled people - the visually impaired included - providing sites are designed with accessibility in mind.

Screen readers also give the visually impaired access via the Internet to emails and messages that can be sent and read aloud without the intervention of a third party. This in turn gives visually impaired people some privacy and thus improves their quality of life. It is difficult to imagine the lack of privacy endured by having to rely on someone else to read all you incoming correspondence and write your outgoing mail (unless to a fellow Braille reader).

The screen reader technology gives visually impaired computer access to current news via internet-based electronic news services designed for the visually able computer users. Braille newspapers were always out-of-date - far more so than printed newspapers - and were expensive to produce for such a small market.

The cost impact of screen reader technology is no longer an issue unlike when it first became available - as Laura Micklus, a user of and advisor on assistive technology recalls: “I saw a demonstration of voice recognition software six years ago, and couldn’t believe the $10,000 price tag” (Syarto, 1998). Now they range from freeware and shareware to commercial packages at US$300 to US$500.

As we turn now to look at some of the negative impacts, it is important to remember that the most positive benefit of assistive technology is that it has made the Internet accessible at all for visually impaired users.

Unfortunately there are some negative impacts for assistive technology. Historically the screen reader technology was developed from the science of character recognition. In the early days of PCs where systems operated using text-based DOS, screen readers did a relatively good job of reading the screen line-at-a-time interpreting most of what was on the screen.

However with the introduction of the Graphical User Interface (GUI) things got rapidly worse for visually impaired users reliant on screen readers. As Scott (2000) says when text-based operating systems were replaced by GUI 'developers assumed that blind people wouldn't use such an interface. What they didn't foresee was the time when textbased interfaces would disappear and blind people would have no option'.

GUI screens hold their data in bitmaps of the screen image (rather than strings of characters in the text-based environment) and this presents screen reader program writers with great challenges that get "more intractable with each new version of the system [GUI]"(Scott, 2000). Modern Web pages are often graphic-intensive and difficult to make sense of when processed by a screen reader 'because screen readers move horizontally across the page, columns, tables, and frames scrambled the text and made it unintelligible' (Valenza, 2000).

Indeed Stein (2000) reports visiting a site using a screen reader and hearing:

> "image ... image ... image ... image ... click here ... image ... image ... image ... image ... enter here ... image ... image ... image ... copyright 1999 all rights reserved ... image"
> while a page using frames sounded like:
>
> "frame ... frame ... frame ..."

Last September, the Royal National Institute for the Blind (RNIB) tested Web sites for accessibility - of the 17 websites tested none met all five of the criteria essential to blind and partially sighted users. They found that:

- Of the 3 banks visited online, all failed.
- The two pizza shops sampled were not accessible online.
- Three out of four clothing shops failed miserably.
- Online supermarkets were not accessible either.

They were particularly disappointed with the online supermarkets as this would be an area of great benefit to visually impaired shoppers. As blind Internet shopper Phil Jenkins says "Shopping in a supermarket is often an unsatisfactory experience, so being able to shop online is a real opportunity, offering independence and choice. Sadly, so far, my experiences on the internet have been almost as bad" (quoted in M2 Presswire, 7 Sept 2000). Tesco were in the process of improving the accessibility of their site (www.tesco.com).

The RNIB say: "it is shocking to discover that the majority of high street stores have failed to make any accommodation for their blind and partially sighted customers" and conclude that "this is particularly disappointing, as blind and partially sighted people have so much to gain from being able to browse and shop online" (M2 Presswire, 7 Sept 2000).

The RNIB finding is supported by an Internet news service CNET that estimates 98% of sites are NOT compatible with the screen-reading technology (Sager, 2000).

Many of these problems can be reduced by raising the awareness of Web designers about the challenges faced by visually impaired users. How many books on web design adequately address the issue of accessibility for visually impaired users? None that I have seen! Fortunately guidelines do exist. The World Wide Web Consortium (W3C) has developed guidelines to help make sites more accessible to people with disabilities - these guidelines, which are under constant review, can be viewed at www.w3.org/WAI.

An excellent tool called 'Bobby', developed by the Massachusetts-based Center for Applied Special Technology, analyses the accessibility to blind users of Web pages or sites. Available on line at www.cast.org/bobby, Bobby checks pages against a subset of the W3C's Web Authoring Guidelines and provide recommendations for accessibility.

Using Bobby to test out Whitireia Polytechnic home page was a sobering exercise - the report clearly shows that site is not accessible to blind users.

Screen readers can only speak the contents of the ALT tag if one is provided - so designers need to ensure that every image (including navigation buttons and banners advertisements) is labelled - and this also proves useful to people who turn off full images to speed up downloading a page.

Screen readers have problems handling frames, tables, pull-down menus, and animated graphics. Users of screen readers can get into trouble when they cannot see the visual search clues, clickable buttons, search boxes and other graphic commands. They find it difficult to work out which bit of spoken text belongs to which part of the screen.

Negative aspects are not just limited to Web sites. Many search engines are not easy (or even possible) for visually-impaired users to use - according to research supported by the Royal National Institute for the Blind (RNIB) in Great Britain "three of the world's most popular Internet search engines are difficult, or in some cases impossible to use if you are blind or partially sighted and use 'adaptive technology" (M2 Presswire, 2 June, 2000). A study by Loughborough University tested Altavista, Yahoo & Infoseek and found failings such as:

- Obtrusive advertising
- Information embedded in a lot of excessive information
- Some images not captioned (Infoseek)
- Yahoo: 'poor contrast' and 'illegible icons'

An RNIB spokesperson said "poorly designed search engines make the Internet a non-starter for many of the UK's 1.7 million people with a serious sight problem" (M2 Presswire, 2 June 2000)

As Kautzman (1998) puts it "for the non-visual user, navigating a Web page is an exercise in memory" especially if attempting to make sense of columns or frames that are read to the user one line at a time - not one column or one frame at a time! Imagine Alicia Cahill-Watts' frustration when visiting her company's home page: "the main Fidelity page has 91 links that her screen reader must rattle off when she visits the site, and that's time consuming" (Tillett, 2001).

Screen readers can also be very tiring to listen to - the synthesised voice lack the natural cadence and expression of a human voice. As one user comments "synthetic speech is particularly poor for proper names and homonyms. And you don't get spelling, punctuation, structure or literary style" (quoted in Eisenberg, 2000). However for the practiced blind user it is possible to understand synthesised speech at 500 words per minute (Scott, 2000).

This has been a brief look at the impact of screen reader technology. Let us now look at the impacts of other assistive output technology - Braille displays and magnification systems.

Refreshable Braille displays allow blind users to 'see' charts and columns of figures. It is faster to use than synthesised speech and allows the user the convenience of jumping over things they are not interested in - a great improvement if the screen has many options (remember the 91 options on Fidelity's home page).

A major negative impact of Braille displays is the high cost. As Dr Dixon says: "my machine cost $12,000. That price is too high for most blind people and their employers" (quoted in Eisenberg, 2000). Prices should fall as the technology becomes more widespread - by last year prices ranged from US$5000 - US$9,000 (Valenza, 2000).

In a bid to reduce the cost of Braille output devices, engineer John W. Roberts of the National Institute of Standards and Technology in Gaithersburg, Maryland has invented a revolutionary new Braille wheel where the reader's hand stays still above a rotating wheel with raised Braille dots displayed on the rim (Eisenberg, 2000). As Mr Roberts says: "the idea was so improbable that we had to build a prototype before anyone would believe it would work" (quoted in Eisenberg, 2000). If this invention moves from the prototype stage and into production it provide a Braille output device at a fraction of the cost of current devices.

Braille printers or embossers are not cheap either - US$3,500 to US$6,000 each.

Screen magnification software allows visually impaired users to magnify items too small for them to see up to the desired degree of magnification. However using it is not always easy. Text may become jagged when greatly enlarged and difficult to read - although true type fonts are generally recommended. Many graphics and even navigation buttons may no longer make sense when greatly enlarged and viewed in parts. Magnification software usually cannot enlarge photographs or video clips.

It is hard to negotiate complex pages using a screen magnifier where only a small portion may be shown at one time. Multi-column layouts may be difficult to follow. Users may find it difficult to locate navigation buttons. Users of magnification software need to be able to remember parts of graphics and to assemble them mentally to get the complete image - a difficult task.

Use of XML format, that allows separation of content and presentation, instead of HTML makes it possible to change colours, font sizes and contrast (to be easier for partially sighted to read).

Many e-commerce executives say they have only recently become aware of the needs of the disabled (Tedeschi, 2001). Indeed as Broadhead (1998) says

"if you have a Web site, chances are you didn't build it to accommodate the needs of vision-impaired Internet users".

Some companies are making an effort to ensure accessibility:

- Since 1997 Amazon.com has provided a text-only version of their site which, their vice-president says, is "not just for people with disabilities, but for all customers who might prefer such a design" (quoted in Tedeschi, 2001).
- Since 1998 the Portico system introduced by General Magic has provided subscribers with "access to voicemail, email, online address books, calendars, stock quotes, and other types of Web content by way of the telephone or cell phone. The system reads Web content over the phone using a speech synthesis system, and users control it using spoken commands" (Stein, 2000).
- VoiceXML was released in August 1999 allows developers to create documents that can be read out loud by suitable browser software. While still in the formative stages, it is expected that eventually it will be submitted to W3C as a standard for voice systems. (Stein, 2000).
- VeCommerce (voice-enabled) an Australasian company provides voice-enabled products incorporating natural language speech recognition - enabling users to communicate via voice commands - current developments underway in New Zealand include TranzRail and AMP.
- In America the Federal Government has announced it will make its sites accessible to people with disabilities - this is not just limited to the visually impaired as discussed in this essay but also the hearing, reading, mobility etc impaired.

In the future the requirement to make the Internet accessible may no longer just be a moral requirement. Indeed in 1999 America On-Line was sued by the National Federation of the Blind - the case settled out of court with the proviso that the next version of their software "was designed from the ground up to support accessibility" (quoted in Tedeschi, 2001).

In Australia a complaint was brought against the Olympic Organising Committee in August 2000 concerning the official Web site of the Sydney Olympic Games. Bruce Maguire claimed that "some of the site's most important pages, including its opening page and the sports schedules, contained images not accompanied by appropriate text descriptions, making them inaccessible through standard screen readers used to translate pages into speech or Braille. Furthermore, scores from the Games were also going to be presented in a format that such readers are unable to handle" (Sager, 2000). Australia's Human Rights and Equal Opportunity Commission ruled that the site had to be made accessible prior to the Games opening on 15 September or be liable for damages.

In New Zealand the Human Rights Act 1993 prohibits discrimination on the bases of physical disability or impairment and applies, among other areas, to the provision of goods and services and education. While I cannot find any test cases relating to disabled peopled accessing the Internet, it is surely only a matter of time.

The benefit to organizations that build accessibility into their Internet sites is not limited to gaining disabled users as customers but has several unexpected spin-offs, including:

- Sites accessible to screen readers are also accessible to users via personal digital assistants (PDAs), cell phones and other non-PC devices (Tillett, 2001). Stein (2000) suggests that voice input technology will allow sighted Internet users to access the web hands-free and eye-free while busy doing something else such as driving a car - for things such as weather forecasts, traffic reports or stock market quotes.
- Another spin-off is that provision of transcripts of audio data required to make sites accessible to blind users, also makes the data searchable.
- Products originally developed for the disabled are finding markets for sighted customers - one recent example is the Voice Mate organiser - a personal digital assistant that uses voice recognition and voice synthesis (Teresko, 2000).

4. CONCLUSION

This essay looks at the impact of assistive technology on visually impaired computer users accessing the Internet. Assistive technology encompasses any technology that gives visually impaired users access to information on a computer - it includes screen reader software using output modes such as voice synthesisers, Braille screens or magnified screen displays. Prior to the development of assistive technology, visually impaired people had to rely on others for much of their access to information.

The development of reasonably priced home computers and the associated assistive technology gave the visually impaired access to the world of computing. Although not perfect by any means, the technology has given the visually impaired access to the Internet and thus access to information they have never had access to before. As McKeefry (1998b) said through assistive technology "a whole segment that was locked out of access to the Internet now has an open door". For a sighted user it is very hard to comprehend the magnitude of this development - imagine the freedom of no longer needing another person to read your mail to you and having the choice to do what you want when you want to - something sighted people take for granted.

However as computers evolved from text-based operating systems - that screen readers could handle well - to the graphical Internet we know today, things got rapidly worse for visually impaired users. McKeefry's (1998b) warned that the "door may swing closed as technology that does not address accessibility evolves and becomes more common on the Internet. A page designer's layout or content decision can easily make or break a site's accessibility".

The future accessibility to the Internet for visually impaired users depends on several factors. Firstly, screen reader technology needs to be continually modified to keep up with new Internet technologies. Secondly Web designers need to become aware of the needs of all potential users - including the visually impaired. The third factor is the likelihood that legislation against discrimination on the grounds of disability may be tested with reference to Web sites and that accessibility will probably become compulsory. Indeed as Sager (2000) says "the Internet has become as important to everyday life as the telephone, making it unfathomable that the disabled be left behind".

I will leave the last word to Al Gore, former Vice-President of United States of America - the country where the Internet was born: "We must eliminate the 'digital divide' for everyone in our society so that we can all benefit from the fruits of our technological advances" (quoted in M2 Presswire, 18 Jan 2001).

BIBLIOGRAPHY

AOL buys Quack.com that enables voice access. (1 Sept 2000). Located: 6 Mar 2001. http://www.stuff.co.nz/inl/index/0,1008,350559a1897,FF.html

Barbian, J. (Jan 2001). Jaws opens learning portal. Training, 38(1), 36.

Broadhead, R. (28 Sept 1998). Seeing opportunities. Computer Dealer News, 14(36), 35.

Dick, T. & Kubiak, E. (May 1997). Issues and aids for teaching mathematics to the blind. The Mathematics Teacher, 90(5), 344-349.

Eisenberg, A. (28 Dec 2000). Reinventing a wheel is likely to cut the cost of e-mail for the blind. The New York Times, G.9.

Gesslein, M., Shafranskaya, S., & Ivanushkin, V. (Aug 2000). Web guidelines from kid experts. Technology & Learning, 21(1), 42.

Kautzman, A.M. (Jun 1998). Virtuous, virtual access: making Web pages accessible too people with disabilities. Searcher, 6(6), 42-45.

M2 Presswire. (2 Jun 2000). RNIB: Blind people are left in the dark by badly designed Internet search engines. Located: 6 Mar 2001. ProQuest available at Whitireia Community Polytechnic Library. http://proquest.umi.com

M2 Presswire. (18 Jul 2000). MINDMAKER: Mindmaker, Inc ships TextAssist 3.0 powered by FlexVoice. Located: 6 Mar 2001. ProQuest available at Whitireia Community Polytechnic Library. http://proquest.umi.com

M2 Presswire. (7 Sep 2000). RNIB: High street shops online fail blind internet users. Located: 6 Mar 2001. ProQuest available at Whitireia Community Polytechnic Library. http://proquest.umi.com

M2 Presswire. (18 Jan 2001). INTERLIANT: American Foundation for the Blind and Interliant mark web accessibility breakthrough; Vice President Gore applauds creation of site featuring enhanced navigability for people with disabilities; Site to serve as role model for businesses, web developers. Located: 7 Mar 2001. ProQuest available at Whitireia Community Polytechnic Library. http://proquest.umi.com

McKeefry, H.L. (5 Oct 1998a). Heart of the matter. Computer Reseller News, 810, 136.

McKeefry, H.L. (5 Oct 1998b). Web's double-edged sword: accessibility vs. complexity. Computer Reseller News, 810, 140.

Microsoft Encarta 96 Encyclopaedia.

Moschovitis, C.J.P. *et al.* (1999). History of the Internet: a chronology, 1843 to the present. Santa Barbara: ABC-CLIO.

Preston, R. (12 Feb 2001). Making sites accessible makes sense for all customers. Internetweek, 848, PG9.

Ray, D.S. & Ray, E.J. (Nov 1998). Adaptive technologies for the visually impaired: the role of technical communicators. Technical Communication, 45(4), 573-579.

Royal Foundation for the Blind. Home page. Located: 6 Mar 2001. http://www.rnzfb.org.nz

Royal Foundation for the Blind. Electronic texts. Located: 6 Mar 2001. http://www.rnzfb.org.nz/AFP/electronic.html

Sager, R.H. (Nov 2000). Don't disable the Web. The American Spectator, 33(9) 62-64.

San Jose offers model for accessible Web pages. (26 Oct 1998). Infoworld, 20(43), 103.

Scott, N. (Dec 2000). Innovations in user interfaces. Dr. Dobb's Journal, 23-27.

Stein, L.D. (Mar 2000). Speak to your browser. Web Techniques, 5(3), 14-17.

Syarto, M.Z. (Nov 1998). The accessible home office. Home Office Computing, 16(11), 48-50.

Tedeschi, B. (1 Jan 2001). Advocates for people with disabilities take online stores to task for not being accessible enough. The New York Times, C.5.

Teresko, J. (21 Feb 2000). Emerging technologies. Industry Week, 249(4), 20.

Tillett, L.S. (12 Feb 2001). Web Accessibility Ripples through IT - Tech mandate to aid disabled benefits broader audience. Internetweek, 848, PG1, PG44+.

Torode, C. (12 Feb 2000). Interliant builds Web site for the blind. Computer Reseller News, 932, 43.

Valenza, J.K. (2000). Surfing blind. Library Journal, Fall, 34-36.

Wlodkowski, T. (Jun 1999). Making CD-ROM's multimedia work for all users. Located: 6 Mar 2001. ProQuest available at Whitireia Community Polytechnic Library. http://proquest.umi.com